

(19)



(11)

EP 3 767 407 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
19.07.2023 Bulletin 2023/29

(51) International Patent Classification (IPC):
H04L 12/40 ^(2006.01) **G05B 19/042** ^(2006.01)
G05B 19/418 ^(2006.01) **H04L 43/0817** ^(2022.01)
H04L 43/0852 ^(2022.01)

(21) Application number: **19766943.5**

(52) Cooperative Patent Classification (CPC):
H04L 12/40019; G05B 19/042; G05B 19/4186;
H04L 12/40169; H04L 43/0817; H04L 43/0852;
H04L 69/40; G05B 2219/31135; Y02P 90/02

(22) Date of filing: **22.01.2019**

(86) International application number:
PCT/JP2019/001744

(87) International publication number:
WO 2019/176286 (19.09.2019 Gazette 2019/38)

(54) FIELD BUS SYSTEM DIAGNOSIS USING PROPAGATION DELAY MEASUREMENTS

DIAGNOSE EINES FELDBUSSYSTEMS UNTER VERWENDUNG VON LAUFZEITMESSUNGEN
DIAGNOSTIC DE SYSTÈME DE BUS DE TERRAIN À L'AIDE DE MESURES DE TEMPS DE PROPAGATION

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

- **SAWADA, Shigenori**
Kizugawa-shi, Kyoto 619-0283 (JP)
- **BABA, Kojiro**
Kizugawa-shi, Kyoto 619-0283 (JP)

(30) Priority: **13.03.2018 JP 2018045124**

(74) Representative: **Becker, Eberhard**
Becker Kurig & Partner
Patentanwälte mbB
Bavariastraße 7
80336 München (DE)

(43) Date of publication of application:
20.01.2021 Bulletin 2021/03

(73) Proprietor: **Omron Corporation**
Kyoto-shi, Kyoto 600-8530 (JP)

(56) References cited:
CN-B- 101 950 175 JP-A- H10 133 966
JP-A- 2012 060 207 JP-A- 2014 146 070
JP-A- 2017 117 267 US-A1- 2015 058 432
US-A1- 2017 185 055 US-B1- 8 072 999

(72) Inventors:
• **YAMAWAKI, Yasushi**
Kizugawa-shi, Kyoto 619-0283 (JP)

EP 3 767 407 B1

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Description

[Citation List]

BACKGROUND

[Patent Literature]

[Technical Field]

5 **[0006]**

[0001] The present invention relates to a technology for communicating control data in a predetermined cycle using a field bus system such as EtherCAT (registered trademark).

[Patent Literature 1]
Japanese Patent Laid-Open No. 2014-146070,
[Patent Literature 2]
10 US Patent Publication No. US 2017/185055 A1
[Patent Literature 3]
US Patent No. US 8072999 B1.

[Background Art]

[0002] Currently, many factory automation (FA) systems are in practical use. The FA systems include, for example, a control device and a plurality of slave devices, as described in Patent Literature 1. The plurality of slave devices is a measurement instrument, a switch, a control driver, or the like, and a control target device is connected to the control driver.

SUMMARY

15

[0007] The present invention is set forth in the independent claims. Preferred embodiments of the invention are described in the dependent claims.

[0003] For example, the control device and the plurality of slave devices communicate control data using a field-bus system. In this case, the control device and the plurality of slave devices communicate control data in a preset control cycle (cyclic cycle). Thereby, punctuality, a real-time property, and high speed of communication of the control data are ensured.

20

[Technical Problem]

[0004] Normally, the control cycle is set by a setting tool such as a PC connected to the control device. In this case, the control cycle is set according to the number and topology of a plurality of slave devices connected to a field bus.

25

[0008] However, the control system may not start up normally depending on content set by the setting tool.
[0009] Accordingly, an objective of the present invention is to provide a technology capable of more reliably realizing normal startup of a control system.

[0005] Patent Literature 2 teaches a process control system includes: a controller; at least one input and output module connected to the controller; and an allowable propagation delay value calculator in the controller, the allowable propagation delay value calculator being configured to calculate, based on the number of input and output modules connected to the controller, an allowable range for propagation delay time between the controller and the input and output module. Patent Literature 3 teaches a method and system for adding a node into a network operating in a cyclic state after one or more nodes have been previously removed without interrupting the synchronous traffic of the remaining nodes on the network is provided. The method includes discovering an added node by sending data to the added node in a downstream timeslot previously assigned to a removed node, the data having a delay value for scheduling a response from the added node to coincide with an upstream timeslot previously assigned to the removed node, thereby avoiding collisions with the synchronous traffic on the network; receiving the response from the added node; configuring the added node in accordance with an original configuration of the removed node; and commencing cyclic operation of the added node.

30

[0010] According to an example of the present disclosure, the control device includes a communication management part, a computation part, and a result output part. The communication management part is configured to manage data communication using cyclic communication conforming to a predetermined communication cycle for a field network. The computation part is configured to measure a propagation delay time from received data of data for actual measurement of propagation delay transmitted to the field network, and detect an operation state of the field network using a measurement result of the propagation delay time. The result output part is configured to output a detection result of the computation part.

35

[0011] In this configuration, an operation state of communication via the field network is detected and provided to a user before a main operation of the control device starts.

45

[0012] According to an example of the present disclosure, the computation part includes a propagation delay time measurement part configured to perform measurement of the propagation delay time from the received data of the data for actual measurement of propagation delay; and a monitoring process execution part configured to perform monitoring of a bandwidth load of the field network from the propagation delay time.

50

55

[0013] In this configuration, the bandwidth load can be obtained together with the propagation delay time as the operation state.

[0014] According to an example of the present disclosure, the computation part includes a diagnosis process execution part configured to perform a diagnosis of cables for use in the field network on the basis of a reception state of the data for actual measurement of propagation delay.

[0015] In this configuration, a cable state diagnosis result can be obtained as the operating state.

[0016] According to an example of the present disclosure, the computation part executes a process of detecting the operation state of the field network when an operation input of a running-in operation is received.

[0017] In this configuration, detection of the operation state of the field network is executed in response to an operation input from the user.

[Advantageous Effects of Invention]

[0018] According to the present invention, normal startup of the control system can be more reliably realized.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

Fig. 1 is a diagram illustrating a schematic configuration of a device in a control system.

Fig. 2 is a block diagram illustrating a hardware configuration of a control device.

Fig. 3 is a functional block diagram of the control device.

Fig. 4 is a flowchart of a control method.

(A) and (B) of Fig. 5 are diagrams illustrating examples of a display screen in a diagnostic mode.

(A) and (B) of Fig. 6 are diagrams illustrating examples of a display screen for a diagnosis result.

DESCRIPTION OF THE EMBODIMENTS

[0020] Hereinafter, embodiments of the present invention will be described with reference to the drawings.

· Application example

[0021] First, an application example of a control device according to an embodiment of the present invention will be described with reference to the drawings. Fig. 3 is a functional block diagram of the control device.

[0022] The control device 10 includes a control part 110, a computation part 120, a communication management part 130, a communication driver 140, a user application processing part 150, and a host communication driver 160, as illustrated in Fig. 3.

[0023] The computation part 120 includes a propagation delay time measurement part 121, a monitoring process

execution part 122, and a diagnosis process execution part 123.

[0024] The control part 110 receives an operation input for a running-in operation from a user via the host communication driver 160. The control part 110 outputs information on the operation input of the running-in operation to the computation part 120 and the communication management part 130.

[0025] The propagation delay time measurement part 121 of the computation part 120 receives the operation input of the running-in operation, generates data for actual measurement of a propagation delay time, and outputs the data for actual measurement of the propagation delay time to the communication management part 130.

[0026] The communication management part 130 transmits the data for actual measurement of the propagation delay time to the field network 30 via the communication driver 140 (see Figs. 1 and 2). The communication management part 130 acquires received data of the data for actual measurement returned from the field network 30, and outputs the received data to the computation part 120.

[0027] The propagation delay time measurement part 121 measures the propagation delay time from the received data. The monitoring process execution part 122 calculates a bandwidth load using a communication cycle set by the user application processing part 150 and the propagation delay time. When the received data cannot be obtained, the diagnosis process execution part 123 starts up a diagnostic mode for cables constituting the field network 30 and executes cable diagnosis.

[0028] The computation part 120 generates result display data including results thereof and outputs the result display data to the control part 110. The control part 110 outputs the result display data to a personal computer 61 via the host communication driver 160, and the personal computer 61 displays the result display data (see Figs. 5(A) and 5(B)). The personal computer 61 (see Fig. 1) can also be caused to execute a process of the computation part 120. In this case, the control device 10 outputs the received data of the data for actual measurement of propagation delay to the personal computer 61 via the host communication driver 160.

[0029] Thereby, the user can confirm an operation state of the field network 30 before a main operation of the control device 10 starts.

· Configuration example

[0030] A control device, a control method, and a control program according to an embodiment of the present invention will be described with reference to the drawings. In the embodiment, a factory automation (FA) system will be described as an example of the control system.

[0031] Fig. 1 is a diagram illustrating a schematic configuration of a device in the control system. The control system 1 includes a control device 10, a slave device 211, a slave device 212, a slave device 213, a field net-

work 30, an information communication network 60, the personal computer 61, and a database device 62, as illustrated in Fig. 1. The number of slave devices is not limited thereto, and may be another number.

[0032] The field network 30 is realized by connecting a plurality of slave devices 211, 212, and 213 with communication cables. In this case, the control device 10 is connected to the slave device 211 via a communication cable, the slave device 211 is connected to the slave device 212 via a communication cable, and the slave device 212 is connected to the slave device 213 via a communication cable, as illustrated in Fig. 1. In other words, the control device 10 is connected to the slave device 212 via the communication cable, the slave device 211, and the communication cable. Further, the control device 10 is connected to the slave device 213 via the communication cable, the slave device 211, the communication cable, the slave device 212, and the communication cable.

[0033] The field network 30 is a network conforming to, for example, EtherCAT (registered trademark) as a network standard. The field network 30 is not limited thereto, and may be a network in which a controller transmits data in one frame to all slave devices logically connected to a ring network, and the slave device performs "on the fly" on the received frame, thereby realizing time synchronization.

[0034] The information communication network 60 is, for example, a network conforming to Ethernet (registered trademark) as a network standard. The control device 10, the personal computer 61, and the database device 62 are connected to one another by an information communication network 60.

[0035] An editing tool for the control program, or the like is installed in the personal computer 61. The personal computer 61 creates, edits, and outputs a control program for the control device 10, the slave device 211, the slave device 212, and the slave device 213. The personal computer 61 outputs the control program to the control device 10. The slave device 211, the slave device 212, and the slave device 213, which are control targets, a control command for each slave device, and the like are described in this control program.

[0036] Further, the personal computer 61 stores an execution program for a running-in operation. The personal computer 61 outputs the execution program for a running-in operation to the control device 10 in response to an operation input from the user. Further, the personal computer 61 displays a diagnosis result for the field network 30 according to the execution program for a running-in operation. An example of a specific display screen will be described below.

[0037] The database device 62 stores, for example, logs of the respective devices acquired from the control device 10. The database device 62 may store the diagnosis result for the field network 30 described above, and a past log of coping methods.

[0038] The control device 10 is specifically realized by,

for example, a programmable logic controller (PLC). The control device 10 may be another device as long as the device communicates control data and data for a diagnosis of the field network 30 via the field network 30.

[0039] The control device 10, for example, generates control data to be communicated via the field network 30 using the control program from the personal computer 61.

[0040] Further, the control device 10, for example, generates the data for a diagnosis of the field network 30 such as the data for actual measurement of propagation delay on the basis of the execution program for a running-in operation from the personal computer 61.

[0041] The slave device 211, the slave device 212, and the slave device 213 are specifically realized by, for example, a servo driver, or a measurement device such as a sensor. These slave devices may be, for example, a robot device or a robot control device connected to the robot device.

[0042] The control device 10, the slave device 211, the slave device 212, and the slave device 213 communicate control data according to a communication cycle preset by the control program or the like, and execute operations and processes in synchronization with a predetermined timing based on the control cycle.

[0043] The control device 10, the slave device 211, the slave device 212, and the slave device 213 perform transmission and reception of the data for actual measurement of propagation delay. Specifically, as outbound processing, the control device 10 transmits the data for actual measurement of propagation delay to the slave device 211. The slave device 211 receives the data for actual measurement of propagation delay from the control device 10, writes a time stamp to the data for actual measurement of propagation delay, and transmits the resultant data for actual measurement of propagation delay to the slave device 212 on the end side. The slave device 212 receives the data for actual measurement of propagation delay from the slave device 211, writes a time stamp to the data for actual measurement of propagation delay, and transmits the resultant data for actual measurement of propagation delay to the slave device 213 on the end side. Thereafter, as a returning process, when the slave device 213 receives the data for actual measurement of propagation delay from the slave device 212, the slave device 213 writes a time stamp to the data for actual measurement of propagation delay, and returns and transmits the resultant data for actual measurement of propagation delay to the slave device 212. The slave device 212 receives the data for actual measurement of propagation delay from the slave device 213, writes a time stamp to the data for actual measurement of propagation delay, and transmits the resultant data for actual measurement of propagation delay to the slave device 211. The slave device 211 receives the data for actual measurement of propagation delay from the slave device 212, writes a time stamp to the data for actual measurement of propagation delay, and transmits the resultant data for actual measurement of propagation delay to the

control device 10.

(Hardware configuration of control device)

[0044] Fig. 2 is a block diagram illustrating a hardware configuration of the control device.

[0045] As a hardware configuration, the control device 10 includes a CPU 101, a memory 102, a storage medium 103, a transmission and reception part 104, and a host communication part 105, as illustrated in Fig. 2. In the control device 10, the CPU 101, the memory 102, the storage medium 103, the transmission and reception part 104, and the host communication part 105 are connected to one another by a data bus 100.

[0046] The CPU 101 reads a system program and a user application program stored in the storage medium 103 into the memory 102 and executes the program, thereby realizing each process of each functional block to be described below. The user application program includes, for example, the control program and the execution program for a running-in operation described above.

[0047] The memory 102 is realized by a volatile storage element such as a DRAM or an SRAM. Further, the storage medium 103 is realized by a nonvolatile storage medium such as a magnetic storage medium or a flash memory.

[0048] The transmission and reception part 104 is an interface of the field network 30 in the control device 10. The transmission and reception part 104 executes transmission and reception (communication) of control data conforming to a cyclic cycle. Further, the transmission and reception part 104 executes transmission and reception of the data for actual measurement of propagation delay.

[0049] The host communication part 105 is an interface of the information communication network 60 in the control device 10 and executes communication with each device (the personal computer 61, the database device 62, or the like) of a host system described above.

(Functional blocks of control device)

[0050] Fig. 3 is a functional block diagram of the control device.

[0051] The control device 10 includes the control part 110, the computation part 120, the communication management part 130, the communication driver 140, the user application processing part 150, and the host communication driver 160, as illustrated in Fig. 3.

[0052] The control part 110 performs, for example, scheduling of an overall operation (process) of the control device 10 to execute operation control of the computation part 120, operation control of the user application processing part 150, and communication management part 130.

[0053] The computation part 120 includes the propagation delay time measurement part 121, the monitoring process execution part 122, and the diagnosis process

execution part 123.

[0054] The propagation delay time measurement part 121 generates the data for actual measurement of propagation delay according to the execution program for a running-in operation, and outputs the data for actual measurement of propagation delay to the communication management part 130. Further, the propagation delay time measurement part 121 acquires the received data of the data for actual measurement of propagation delay via the communication management part 130. The propagation delay time measurement part 121 calculates a propagation delay time of each slave device and a propagation delay time due to a plurality of slave device groups from the time stamp written to the received data.

[0055] The monitoring process execution part 122 calculates a bandwidth load status of the field network 30 from the propagation delay time according to the execution program for a running-in operation. Specifically, the monitoring process execution part 122 calculates the bandwidth load status from a ratio of the propagation delay time of all frames transmitted within one cycle to the preset communication cycle.

[0056] The diagnosis process execution part 123 starts up a cable diagnosis mode to execute the cable diagnosis when the received data cannot be acquired within a predetermined time based on the communication cycle despite the fact that the data for actual measurement of propagation delay has been transmitted. A known method can be used for cable diagnosis.

[0057] The computation part 120 generates a diagnosis result using processing results of the propagation delay time measurement part 121, the monitoring process execution part 122, and the diagnosis process execution part 123. The computation part 120 outputs the diagnosis result to the control part 110, and the control part 110 outputs the diagnosis result to the personal computer 61 connected to the information communication network 60 via the host communication driver 160.

[0058] The communication management part 130 executes scheduling of communication of the control data. Further, the communication management part 130 executes management of transmission and reception of the data for actual measurement of propagation delay.

[0059] The communication driver 140 executes control of the transmission and reception part 104 to communicate the control data via the field network 30 according to the cyclic cycle. Further, the communication driver 140 communicates the data for actual measurement of propagation delay via the field network 30.

[0060] The user application processing part 150 executes the user application program including the control program and the execution program of a running-in operation described above.

[0061] In such a configuration, the control device 10 executes the running-in operation to generate a diagnosis result for the field network 30 before a main operation. The control device 10 outputs the diagnosis result to the personal computer 61, and the personal computer 61

displays the diagnosis result.

[0062] Fig. 4 is a flowchart of the control method.

[0063] As illustrated in Fig. 4, the personal computer 61 receives an operation input in a startup support mode (S11). The personal computer 61 executes selection of a diagnosis target item (S12). When the personal computer 61 receives the execution operation (S13: YES), the personal computer 61 instructs the control device 10 to execute the diagnosis of the field network 30.

[0064] The control device 10 measures the propagation delay time and executes diagnosis using the propagation delay time (S14). The control device 10 outputs a diagnosis result to the personal computer 61, and the personal computer 61 displays the diagnosis result (S15).

[0065] Next, an example of the display screen of the operation input in a diagnostic mode will be described. Figs. 5(A) and 5(B) are diagrams illustrating an example of a display screen in the diagnostic mode.

[0066] A Home screen for startup support as illustrated in (A) of FIG. 5 is displayed on a screen of the personal computer 61. An icon for receiving an operation input for a display of an abnormality status, an icon for receiving an operation input for abnormality release, an icon for receiving selection of a display of system information, and an icon for receiving execution of the startup support mode are displayed on the Home screen, as illustrated in (A) of Fig. 5.

[0067] When the user operates the icon for receiving execution of the startup support mode, the startup support mode in which an operation status of the field network 30 is detected is executed. When the execution of the startup support mode is received, a screen illustrated in (B) of Fig. 5 is displayed.

[0068] A plurality of items to be executed, a box for selecting whether or not the plurality of items is executed, an icon for receiving an operation input for execution, and an icon for receiving an operation input for returning to the Home screen are displayed on the startup support screen, as illustrated in (B) of Fig. 5.

[0069] The plurality of items includes items such as "execute all items", "execute a running-in operation", "execute cable diagnosis", and "monitor bandwidth load information". When the user selects a box corresponding to each of these items, the selected item is executed.

[0070] For example, when "execute a running-in operation" is selected, the control device 10 executes the running-in operation using the field network 30. In this case, transmission and reception of the data for actual measurement of propagation delay are performed.

[0071] When [Execute cable diagnosis] is selected, the control device 10 executes the cable diagnosis for the field network 30. Specifically, when the data for actual measurement of propagation delay is not returned within the predetermined time based on the communication cycle, the control device 10 determines that cable diagnosis is necessary, and executes the cable diagnosis mode. When the data for actual measurement of propagation

delay is returned within the predetermined time based on the communication cycle, the control device 10 outputs a diagnosis result indicating that there is no problem in the cables.

[0072] When [Monitor bandwidth load information] is selected, the control device 10 transmits or receives the data for actual measurement of propagation delay and acquires the time stamp. The control device 10 calculates the propagation delay time from the time stamp, and calculates the bandwidth load from a ratio of the propagation delay time to the preset communication cycle.

[0073] These items are executed by an execution icon being selected, after selection.

[0074] Next, an example of a display screen of a diagnosis result will be described. Figs. 6(A) and 6(B) are diagrams illustrating an example of a display screen of a diagnosis result.

[0075] In the running-in operation, a progress status of the running-in operation, that is, a progress status of the diagnosis based on the selected item is displayed, as illustrated in (A) of Fig. 6. Further, in the running-in operation, a currently executed process and a currently known diagnosis result are displayed in an area under the progress status.

[0076] When the running-in operation is completed, a progress status of the running-in operation (100% completed) is displayed, as illustrated in (B) of Fig. 6. Further, a diagnosis result is displayed in an area under the progress status after ending of the running-in operation.

[0077] Such a display enables the user to recognize how the field network 30 operates, before a main operation starts, by setting the control program. Thereby, normal startup of the control system can be realized more reliably.

[Reference Signs List]

[0078]

- 1 Control system
- 10 Control device
- 12 Computation part
- 30 Field network
- 60 Information communication network
- 61 Personal computer
- 62 Database device
- 100 Data bus
- 101 CPU
- 102 Memory
- 103 Storage medium
- 104 Transmission and reception part
- 105 Host communication part
- 110 Control part
- 120 Computation part
- 121 Propagation delay time measurement part
- 122 Monitoring process execution part
- 123 Diagnosis process execution part
- 130 Communication management part

140 Communication driver
 150 User application processing part
 160 Host communication driver
 211, 212, 213 Slave device

Claims

1. A control device (10) that comprises:

a communication management part (130) configured to manage data communication using cyclic communication conforming to a predetermined communication cycle for a field network (30), wherein the control device (10) is connectable to a slave device (211, 212, 213) via the field network (30), and the control device (10) and the slave device are configured to perform communication of control data via the field network (30);

a computation part (120) configured to measure a propagation delay time from received data of data for actual measurement of propagation delay transmitted to the field network, and detect an operation state of the field network (30) using a result of the propagation delay time; and
 a result output part (110) configured to output a detection result of the computation part (120), wherein the computation part (120) comprises:

a propagation delay time measurement part (121) configured to generate the data for actual measurement of propagation delay, to output the data for actual measurement of propagation delay to the slave device (211, 212, 213) via the communication management part (130), to acquire the received data of the data for actual measurement of propagation delay via the communication management part (130), and to calculate the propagation delay time of the slave device (211, 212, 213) from the received data of the data for actual measurement of propagation delay from the time stamp written to the received data; and

a monitoring process execution part (122) configured to perform monitoring of a bandwidth load of the field network (30) from the propagation delay time, wherein the monitoring process execution part (122) is configured to calculate the bandwidth load from a ratio of the propagation delay time of all frames transmitted within one cycle to the predetermined communication cycle.

2. The control device (10) according to claim 1, wherein the computation part (120) comprises a diagnosis process execution part (123) configured to perform

a diagnosis of cables for use in the field network (30) on the basis of a reception state of the data for actual measurement of propagation delay, wherein the diagnosis process execution part (123) is configured to start the diagnosis of the cables when the data for actual measurement of the propagation delay has been transmitted to the slave device (211, 212, 213) and the received data is not acquired within a predetermined time.

3. The control device (10) according to any one of claims 1 to 2, wherein the computation part (120) is configured to execute a process of detecting the operation state of the field network (30) when an operation input of a running-in operation is received.

4. A control method comprising:

a communication management process of managing, by a communication management part (130) of a control device (10), data communication using cyclic communication conforming to a predetermined communication cycle for a field network (30), wherein the control device (10) is connected to a slave device (211, 212, 213) via the field network (30), and the control device (10) and the slave device are configured to perform communication of control data via the field network (30);

a process of generating, by a propagation delay time measurement part (121) of a computation part (120) of the control device (10), data for actual measurement of propagation delay, a process of outputting, by the propagation delay time measurement part (121), the data for actual measurement of propagation delay to the slave device (211, 212, 213) via the communication management part (130);

a process of acquiring, by the propagation delay time measurement part (121), received data of the data for actual measurement of propagation delay via the communication management part (130);

a process of calculating, by the propagation delay time measurement part (121), a propagation delay time of the slave device (211, 212, 213) from the time stamp written to the received data; a process of performing, by a monitoring process execution part (122) of the computation part (120) of the control device (10), monitoring of a bandwidth load of the field network (30) from the propagation delay time, wherein the bandwidth load is calculated from a ratio of the propagation delay time of all frames transmitted within one cycle to the predetermined communication cycle;

a computation process of detecting, by the computation part (120), an operation state of the field

network (30) using a result of the propagation delay time; and
 a result output process of outputting, by a result output part (110) of the control device (10), a detection result obtained in the computation process.

5. A control program comprising instructions which, when the program is executed by a computer, cause the computer to carry out all the steps of the method according to claim 4.

Patentansprüche

1. Steuervorrichtung (10), die umfasst:

ein Kommunikationsverwaltungsteil (130), das konfiguriert ist, um die Datenkommunikation unter Verwendung einer zyklischen Kommunikation entsprechend einem vorbestimmten Kommunikationszyklus für ein Feldnetzwerk (30) zu verwalten, wobei die Steuervorrichtung (10) über das Feldnetzwerk (30) mit einer Slave-Vorrichtung (211, 212, 213) verbunden werden kann und die Steuervorrichtung (10) und die Slave-Vorrichtung konfiguriert sind, um Kommunikation von Steuerdaten über das Feldnetzwerk (30) durchzuführen;

ein Berechnungsteil (120), das konfiguriert ist, um eine Ausbreitungsverzögerungszeit aus empfangenen Daten von Daten zu der tatsächlichen Messung der Ausbreitungsverzögerung, übertragen an das Feldnetzwerk, zu messen und einen Betriebszustand des Feldnetzwerks (30) unter Verwendung eines Ergebnisses der Ausbreitungsverzögerungszeit zu erfassen; und

ein Ergebnisausgabeteil (110), das konfiguriert ist, um ein Erfassungsergebnis des Berechnungsteils (120) auszugeben, wobei das Berechnungsteil (120) umfasst:

ein Ausbreitungsverzögerungszeit-Mess-
 teil (121), das konfiguriert ist, um die Daten für die tatsächliche Messung der Ausbreitungsverzögerung zu erzeugen, die Daten für die tatsächliche Messung der Ausbreitungsverzögerung über das Kommunikationsverwaltungsteil (130) an die Slave-Vorrichtung (211, 212, 213) auszugeben, die empfangenen Daten der Daten für die tatsächliche Messung der Ausbreitungsverzögerung über das Kommunikationsverwaltungsteil (130) zu erfassen und die Ausbreitungsverzögerungszeit der Slave-Vorrichtung (211, 212, 213) aus den empfangenen Daten der Daten für die tatsächliche Mes-

sung der Ausbreitungsverzögerung aus dem Zeitstempel, geschrieben zu den empfangenen Daten, zu berechnen; und ein Überwachungsprozess-Ausführungsteil (122), das konfiguriert ist, um eine Überwachung einer Bandbreitenauslastung des Feldnetzwerks (30) aus der Ausbreitungsverzögerungszeit durchzuführen, wobei das Überwachungsprozess-Ausführungsteil (122) konfiguriert ist, um die Bandbreitenauslastung aus einem Verhältnis der Ausbreitungsverzögerungszeit aller Frames, übertragen innerhalb eines Zyklus, zu dem vorbestimmten Kommunikationszyklus zu berechnen.

2. Steuervorrichtung (10) gemäß Anspruch 1, wobei das Berechnungsteil (120) ein Diagnoseprozess-Ausführungsteil (123) umfasst, das konfiguriert ist, um eine Diagnose von Kabeln zur Verwendung in dem Feldnetzwerk (30) basierend auf einem Empfangszustand der Daten für die tatsächliche Messung der Ausbreitungsverzögerung durchzuführen, wobei das Diagnoseprozess-Ausführungsteil (123) konfiguriert ist, um die Diagnose der Kabel zu starten, wenn die Daten für tatsächliche Messung der Ausbreitungsverzögerung an die Slave-Vorrichtung (211, 212, 213) übertragen worden sind und die empfangenen Daten nicht innerhalb einer vorbestimmten Zeit erfasst werden.
3. Steuervorrichtung (10) gemäß einem der Ansprüche 1 bis 2, wobei das Berechnungsteil (120) konfiguriert ist, um einen Prozess zum Erfassen des Betriebszustands des Feldnetzwerks (30) auszuführen, wenn eine Betriebseingabe eines Einfahrvorgangs empfangen wird.

4. Steuerungsverfahren, das umfasst:

einen Kommunikationsverwaltungsprozess des Verwaltens, durch ein Kommunikationsverwaltungsteil (130) einer Steuervorrichtung (10), einer Datenkommunikation unter Verwendung einer zyklischen Kommunikation, die einem vorbestimmten Kommunikationszyklus für ein Feldnetzwerk (30) entspricht, wobei die Steuervorrichtung (10) mit einer Slave-Vorrichtung (211, 212, 213) über das Feldnetzwerk (30) verbunden ist, und die Steuervorrichtung (10) und die Slave-Vorrichtung konfiguriert sind, um eine Kommunikation von Steuerdaten über das Feldnetzwerk (30) durchzuführen;
 ein Prozess zum Erzeugen von Daten für die tatsächliche Messung der Ausbreitungsverzögerung durch ein Ausbreitungsverzögerungszeit-Mess-
 teil (121) eines Berechnungsteils (120) der Steuervorrichtung (10),

einen Prozess des Ausgebens der Daten für die tatsächliche Messung der Ausbreitungsverzögerung durch das Ausbreitungsverzögerungszeit-Messteil (121) an die Slave-Vorrichtung (211, 212, 213) über das Kommunikationsverwaltungsteil (130);

einen Prozess des Erfassens der empfangenen Daten der Daten für die tatsächliche Messung der Ausbreitungsverzögerung durch das Ausbreitungsverzögerungszeit-Messteil (121) über das Kommunikationsverwaltungsteil (130);

einen Prozess des Berechnens, durch das Ausbreitungsverzögerungszeit-Messteil (121), einer Ausbreitungsverzögerungszeit der Slave-Vorrichtung (211, 212, 213) von dem Zeitstempel, geschrieben zu den empfangenen Daten; einen Prozess, bei dem durch ein Überwachungsprozess-Ausführungsteil (122) des Berechnungsteils (120) der Steuervorrichtung (10) Überwachen einer Bandbreitenauslastung des Feldnetzwerks (30) aus der Ausbreitungsverzögerungszeit durchgeführt wird, wobei die Bandbreitenauslastung aus einem Verhältnis der Ausbreitungsverzögerungszeit aller Frames, übertragen innerhalb eines Zyklus zu dem vorbestimmten Kommunikationszyklus, berechnet wird;

einen Berechnungsprozess des Erfassens eines Betriebszustands des Feldnetzwerks (30) durch das Berechnungsteil (120) unter Verwendung eines Ergebnisses der Ausbreitungsverzögerungszeit; und

einen Ergebnisausgabeprozess des Ausgebens eines Erfassungsergebnisses, erhalten in dem Berechnungsprozess, durch ein Ergebnisausgabeteil (110) der Steuervorrichtung (10).

5. Steuerprogramm, umfassend Anweisungen, die, wenn das Programm von einem Computer ausgeführt wird, den Computer veranlassen, alle Schritte des Verfahrens gemäß Anspruch 4 auszuführen.

Revendications

1. Dispositif de commande (10) qui comprend :

une partie de gestion de communication (130) configurée pour gérer une communication de données en utilisant une communication cyclique conforme à un cycle de communication prédéterminé pour un réseau de terrain (30), dans lequel le dispositif de commande (10) peut être relié à un dispositif esclave (211, 212, 213) via le réseau de terrain (30), et le dispositif de commande (10) et le dispositif esclave sont configurés pour réaliser une communication de données de commande via le réseau de terrain

(30) ;
 une partie de calcul (120) configurée pour mesurer un temps de retard de propagation à partir de données reçues de données de mesure réelle de retard de propagation transmises au réseau de terrain, et détecter un état de fonctionnement du réseau de terrain (30) en utilisant un résultat du temps de retard de propagation ; et une partie de délivrance de résultat (110) configurée pour délivrer un résultat de détection de la partie de calcul (120),
 dans lequel la partie de calcul (120) comprend :

une partie de mesure de temps de retard de propagation (121) configurée pour générer les données de mesure réelle de retard de propagation, pour délivrer les données de mesure réelle de retard de propagation au dispositif esclave (211, 212, 213) via la partie de gestion de communication (130), pour acquérir les données reçues des données de mesure réelle de retard de propagation via la partie de gestion de communication (130), et pour calculer le temps de retard de propagation du dispositif esclave (211, 212, 213) à partir des données reçues des données de mesure réelle de retard de propagation d'après l'horodatage écrit dans les données reçues ; et
 une partie d'exécution de processus de surveillance (122) configurée pour réaliser une surveillance d'une charge de bande passante du réseau de terrain (30) à partir du temps de retard de propagation, dans lequel la partie d'exécution de processus de surveillance (122) est configurée pour calculer la charge de bande passante à partir d'un rapport du temps de retard de propagation de toutes les trames transmises à l'intérieur d'un cycle sur le cycle de communication prédéterminé.

2. Dispositif de commande (10) selon la revendication 1, dans lequel la partie de calcul (120) comprend une partie d'exécution de processus de diagnostic (123) configurée pour réaliser un diagnostic de câbles à utiliser dans le réseau de terrain (30) sur la base d'un état de réception des données de mesure réelle de retard de propagation, dans lequel la partie d'exécution de processus de diagnostic (123) est configurée pour commencer le diagnostic des câbles lorsque les données de mesure réelle de retard de propagation ont été transmises au dispositif esclave (211, 212, 213) et les données reçues ne sont pas acquises au cours d'un temps prédéterminé.
3. Dispositif de commande (10) selon la revendication 1 ou 2, dans lequel la partie de calcul (120) est con-

figurée pour exécuter un processus de détection de l'état de fonctionnement du réseau de terrain (30) lorsqu'une entrée d'opération d'une opération en cours d'exécution est reçue.

4. Procédé de commande, comprenant :

un processus de gestion de communication pour gérer, par une partie de gestion de communication (130) d'un dispositif de commande (10), une communication de données en utilisant une communication cyclique conforme à un cycle de communication prédéterminé pour un réseau de terrain (30), dans lequel le dispositif de commande (10) est relié à un dispositif esclave (211, 212, 213) via le réseau de terrain (30), et le dispositif de commande (10) et le dispositif esclave sont configurés pour réaliser une communication de données de commande via le réseau de terrain (30) ;

un processus de génération, par une partie de mesure de temps de retard de propagation (121) d'une partie de calcul (120) du dispositif de commande (10), de données de mesure réelle de retard de propagation ;

un processus de délivrance, par la partie de mesure de temps de retard de propagation (121), des données de mesure réelle de retard de propagation au dispositif esclave (211, 212, 213) via la partie de gestion de communication (130) ;

un processus d'acquisition, par la partie de mesure de temps de retard de propagation (121), de données reçues des données de mesure réelle de retard de propagation via la partie de gestion de communication (130) ;

un processus de calcul, par la partie de mesure de temps de retard de propagation (121), d'un temps de retard de propagation du dispositif esclave (211, 212, 213) d'après l'horodatage écrit dans les données reçues ;

un processus de réalisation, par une partie d'exécution de processus de surveillance (122) de la partie de calcul (120) du dispositif de commande (10), d'une surveillance d'une charge de bande passante du réseau de terrain (30) à partir du temps de retard de propagation, dans lequel la charge de bande passante est calculée à partir d'un rapport du temps de retard de propagation de toutes les trames transmises à l'intérieur d'un cycle sur le cycle de communication prédéterminé ;

un processus de calcul pour détecter, par la partie de calcul (120), un état de fonctionnement du réseau de terrain (30) en utilisant un résultat du temps de retard de propagation ; et

un processus de délivrance de résultat pour délivrer, par une partie de délivrance de résultat (110) du dispositif de commande (10), un résultat

de détection obtenu dans le processus de calcul.

5. Programme de commande comprenant des instructions qui, lorsque le programme est exécuté par un ordinateur, amènent l'ordinateur à effectuer toutes les étapes du procédé selon la revendication 4.

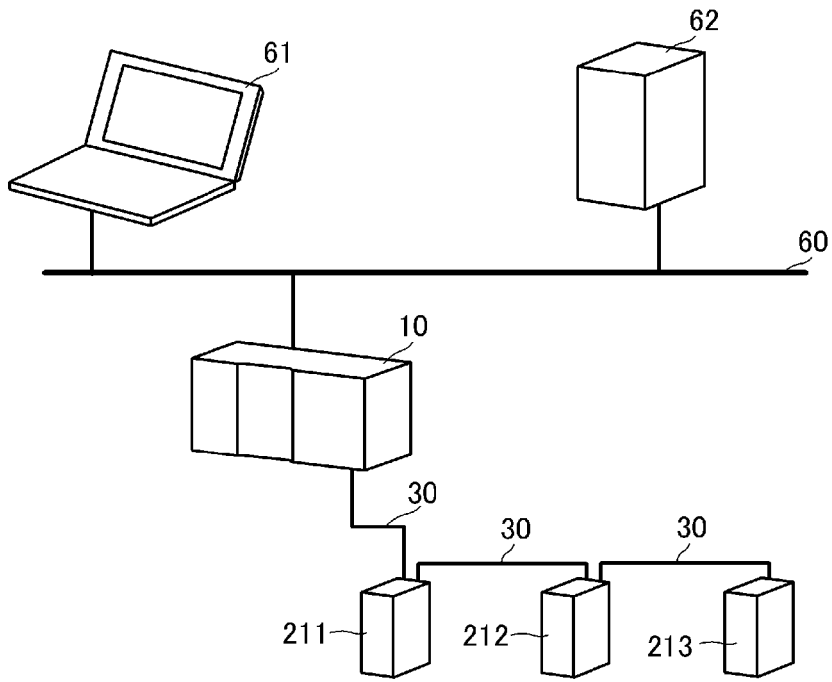


FIG. 1

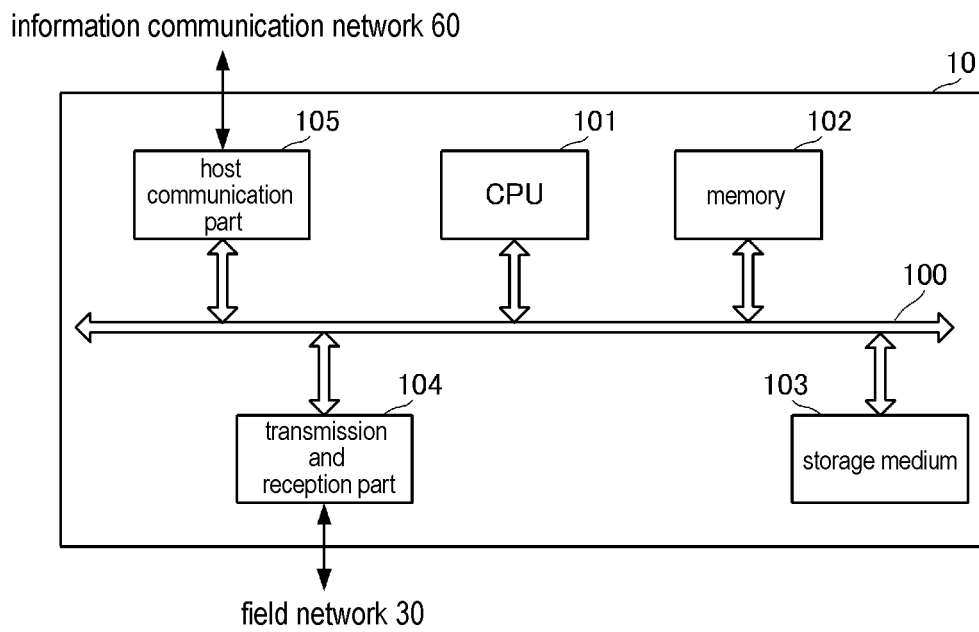


FIG. 2

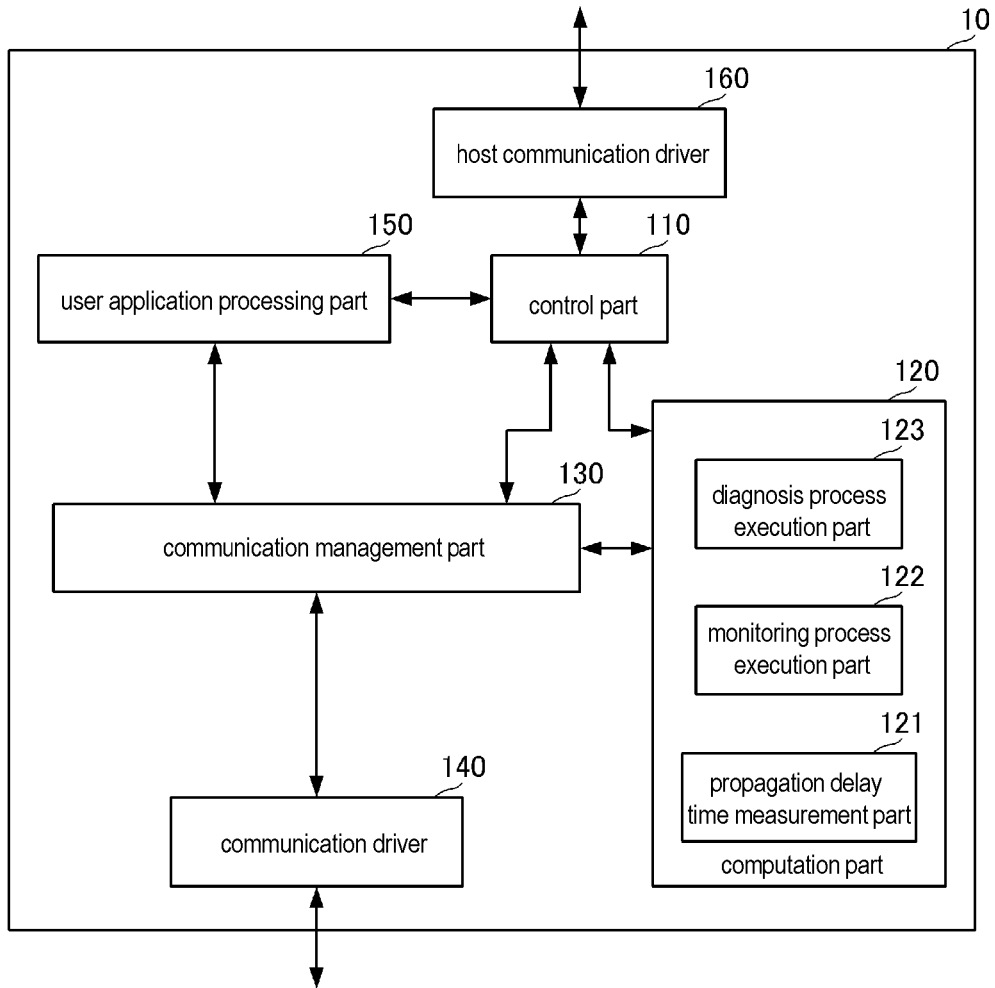


FIG. 3

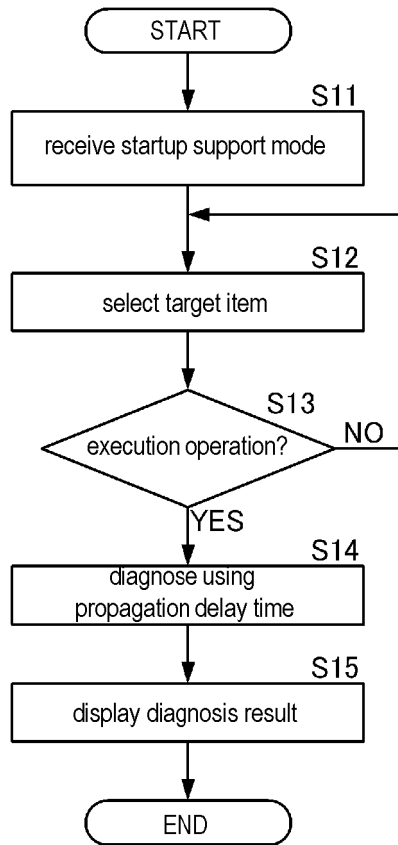
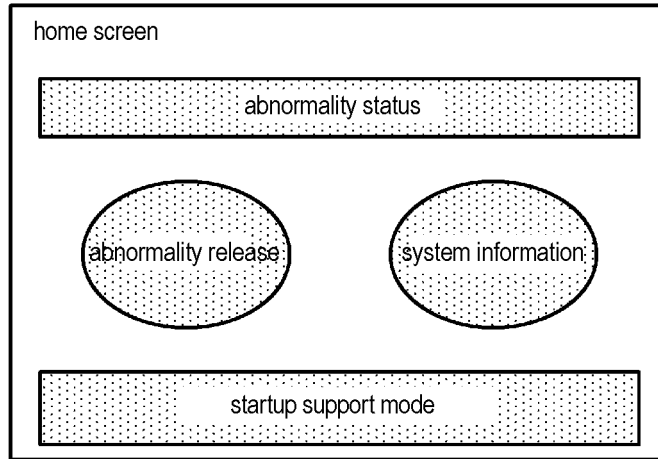


FIG. 4

(A)



(B)

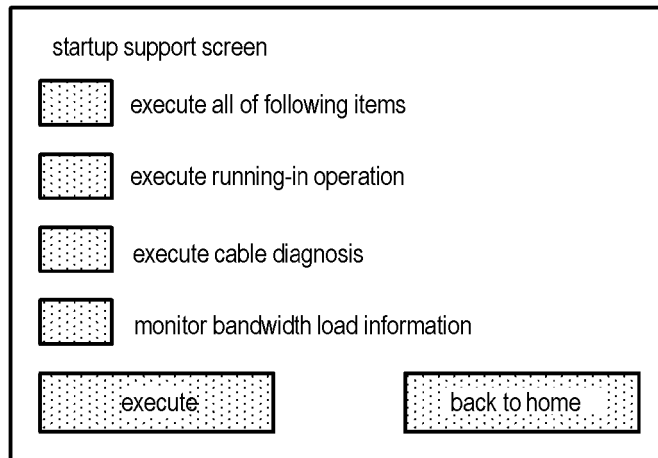
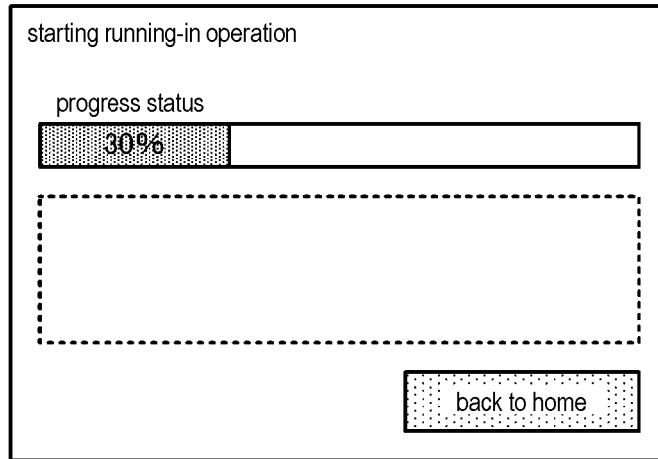


FIG. 5

(A)



(B)

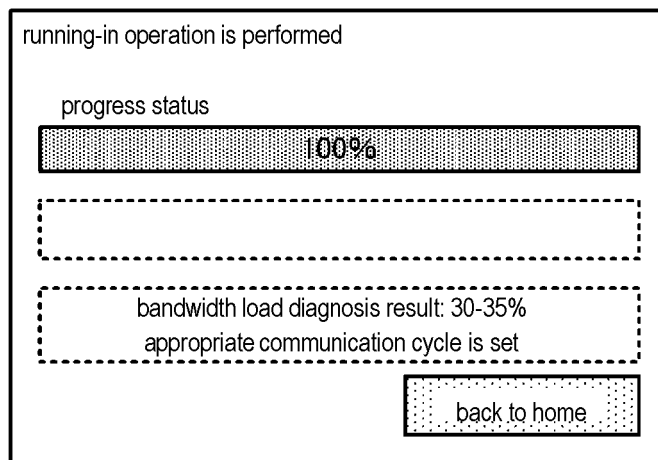


FIG. 6

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2014146070 A [0006]
- US 2017185055 A1 [0006]
- US 8072999 B1 [0006]